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## METHODS AND RESULTS OF FIELD INSECTICIDE WORK AGAINST THE SAN JOSE SCALE, 1899–1902.

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On April 11, 1899, an emergency bill was approved by Governor John R. Tanner of Illinois requiring the State Entomologist to "treat and disinfect once thoroughly," at the expense of the State, all orchard property which that officer had reason to believe had become infested with the San Jose scale before the year 1899, a fact which marked a new departure in the struggle for the control of the San Jose scale in Illinois. Unfortunately, the appropriation of $6,000 made for the expenses of this work was insufficient for its purpose, being indeed but half the sum estimated by me as necessary to give a single insecticide treatment to all the premises then known to be infested. This fact put an effectual bar upon preliminary experiments with insecticides, since it was evidently my duty to apply the appropriation at once and as far as it would go to the immediate purpose expressed in the law, that of a thorough insecticide treatment of infested premises.

Being thus limited to action on lines fixed by the existing state

of our knowledge of insecticide methods, it was my first duty to make choice of the procedure which seemed most likely to enable me to exterminate the scale locally by a single treatment. This choice necessarily lay between liquid and gaseous insecticides, applied by spraying and by fumigation respectively.

The liquid insecticides well enough known at the time to make them practically available for the destruction of the San Jose scale were the whale-oil soap solution and the emulsions or mechanical mixtures of kerosene and water. Crude petroleum was then coming into use, it is true, but the results reported were too variable to entitle it to confidence as both efficient and safe. To exterminate the scale in orchards with a liquid insecticide required that the fluid should be so distributed as to reach every scale on every tree in quantity sufficient to kill the insect. This was obviously an impossible task, especially if we take into account the frequency with which these minute scales are secreted under bark, behind buds, etc.; and this conclusion was confirmed by two years of previous experience with the use of whale-oil soap, during which orchards and town lots at twenty-one localities in Illinois had been carefully and thoroughly treated by two of my assistants, Prof. H. E. Summers, now State Entomologist of Iowa, and Mr. R. W. Braucher, a graduate in horticulture from the University of Illinois. Subsequent inspections of the premises treated disclosed the fact that the extermination of the scale was accomplished in no case except where every visibly infested tree and shrub was destroyed, together with all adjacent vegetation to which the scale might possibly have spread.

The fumigation method had this theoretical advantage over that with the liquid spray, that an insecticide vapor set free under a close tent enveloping the infested tree would be carried by spontaneous diffusion to all parts of the inclosed space, and would thus presumably reach every particle of the infested surface and kill every scale, provided the operation were intelligently and carefully conducted. There seemed, in short, a reasonable possibility that expert fumigation would exterminate locally where the conditions were not unfavorable to thorough work, while such a result seemed clearly impossible with the liquid spray. I consequently decided to make a trial of orchard fumigation with hydrocyanic acid gas, applied after the method which had been in use for several years in the citrus orchards of the Pacific coast.

The opinion current among entomologists with respect to fumigation as an orchard method was well shown by statements of experimental results appearing at about this time, and especial-

ly by those published in August, 1898, in Bulletin 57 of the Maryland Experiment Station, and in the fall of that year in Bulletin No. 17 of the Entomological Division of the U. S. Department of Agriculture. In the first of these bulletins, entitled "A Report on the San Jose Scale in Maryland and Remedies for its Suppression and Control," Prof. W. G. Johnson, State Entomologist of Maryland, gives an account of various experiments with this insecticide gas, made in the fall of 1897 and the spring of 1898 on bearing orchard trees in Maryland. As a conclusion from experiments on fifty-three dwarf Bartlett pear-trees conducted from September 27 to October 1 by liberating gas under inclosing tents, he says (p. 86) that "the San Jose scale is entirely destroyed by the gas when used on calm, dry, sunny or cloudy days"; that "the cost of treatment, aside from the equipment, is less than that for whale-oil soap"; that "trees treated at night with very strong doses of gas do not have the foliage or dormant leaf and fruit buds affected at all, even where double the amount of gas ordinarily used is generated"; and that "trees treated in the morning before 9 a. m. and in the afternoon after 4 p. m. have the foliage very little affected by the gas." These tests were thought by him so gratifying that a meeting of those especially interested was called for a demonstration of the operation, and at a dinner served by the owner of the infested premises all the speakers "were unanimous in the opinion that the experiment was complete in every respect." In a later report on this same experiment, read August 19, 1898, at the Tenth Annual Meeting of the Association of Economic Entomologists, Professor Johnson says: *

"In order that I might report the definite and final results of these experiments, I made a careful examination of every tree in the orchard on Tuesday and Wednesday of this week. Where there were hundreds and thousands of scales breeding on the trees at this time last year not one can be found now, except upon trees under 5 feet in height and on those fumigated when the foliage was wet with dew or fog or immediately after a rain, and even on these trees the young larvæ are very few as compared with their number at this time last year. Where the fruit was much pitted and scarred by the scale last year not one has been seen upon a pear thus far this season.

"In all, the experiment is thoroughly satisfactory, in that it demonstrates by actual trial that this method can be used in our largest bearing orchards, even under the most adverse conditions, with excellent results."

* Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., pp. 41 and 42.

Fourteen very badly infested plum-trees were also treated March 17 and 18, 1898, with hydrocyanic acid gas liberated under tents, and no living scales had been found on them three months later. "The general outcome of these experiments," says Professor Johnson,* "up to the present time, June 15, is so far satisfactory. We cannot hope to find a remedy for the San Jose scale that is more effective than hydrocyanic acid gas." Referring to this experiment again† August 19, five months after the treatment was given, he says:

"The gas can also be used in the spring in peach, plum, and apple orchards after the buds have begun to unfold. A block of one hundred six-year old plum-trees at Annapolis Junction was fumigated March 17 and 18, 1898, and up to the present time not a living scale has been found upon any trees, except those sprayed with 50 and 100 per cent. gasoline. The trees in this orchard were very badly infested, the most of them being so literally covered it was impossible to see the bark at any point on the trunk and larger branches.

"Other experiments were conducted in scale-infested bearing orchards in May, June, and July, the results of which cannot be finally reported at this time, except that no living scales have been found upon any of the fumigated trees."

The operations reported in the present paper can scarcely be called experiments, since they were an attempt to make practical application in the field of methods based on the experimental work and practical experience of others. Those with hydrocyanic acid gas may be taken, however, as a test of the fumigation method as applied to common orchards and fruit plantations in southern Illinois under conditions more favorable in some respects and less favorable in others than those of ordinary orchard practice. A considerable series of operations was carried on over a large territory by a single party under the direction of one foreman especially selected and carefully instructed for this work, and his management was doubtless more intelligent and exact than that of the ordinary foreman or owner of an orchard would have been. On the other hand, the conditions which he had to meet were of course much more varied than those to which any single orchardist would be subject, and the limitations of time and expense were such that the work must move steadily forward whenever at all practicable—a fact which made it impossible to choose favorable weather and

* Md. Bull. 57, p. 90.

† Bull. No. 17, N. S., U. S. Dept. Agr., Div. Ent., p. 42.

to suspend operations temporarily when it was likely that the best results could not be obtained.

It has seemed to me, nevertheless, that the outcome of this campaign is well worthy of report, since it indicates with approximate fairness what can be accomplished by practical work on a large scale by the intelligent fruit grower so unfortunate as to have become the victim of the San Jose scale. Owing to the fact that these were not regarded as experimental but practical operations only, the notes of the work were not as full as I could now desire. They were, however, carefully made by competent men, and are entirely reliable so far as they go.

### Experience with Orchard Fumigation.

Having decided on an extensive practical trial of orchard fumigation with hydrocyanic acid gas, I found it necessary first to provide expert advice and supervision with respect to the practical operation, with which none of my office force had any personal acquaintance, and for this purpose, after considerable correspondence, I secured the aid of Prof. Charles W. Woodworth, Assistant Professor of Entomology at the University of California and Entomologist of the California Agricultural Experiment Station. Professor Woodworth being a graduate of the University of Illinois was well known to me personally, and was particularly useful to us because he had made a special study of fumigation operations in California. He had, in fact, published an elaborate bulletin on "Orchard Fumigation,"* which was the principal reliance of economic entomologists interested, and remains to-day the best brief practical treatise on the subject.

Arriving in May, 1899, he inspected parts of our infested districts, planned our equipment and superintended its manufacture, coached our first fumigating squad, and supervised its practice work—first on the Experiment Station farm, at Urbana, and later on premises infested by the San Jose scale at Monticello, in Piatt county.

*Description of Equipment.*—Our tents to cover infested trees and confine the insecticide gas liberated under them were all made of eight-ounce canvas, treated in two different ways to make them impermeable to the gas. The first lot were thoroughly sized with flour paste and covered, when dry, with a thin black paint; and the second lot were saturated with boiled linseed oil and left spread out until dry. The latter method of preparation proved the more satisfactory and durable. The paint was likely to wear and crack

* Bull. 122, Calif. Agr. Exper. Station.

with use, and the sizing and painting were more laborious and costly than filling with oil. The latter operation was conveniently and rapidly performed (as shown in Plate I.) by the aid of a common spray pump provided with an adjustable nozzle. Great care was necessary that the oil in the tents should be thoroughly dried out before they were folded, as otherwise they were liable to heat, with the effect to destroy the cloth if not to set up spontaneous combustion.

The fumigation outfit consisted of forty-seven tents, three pairs of lifting poles, and several sets of generators for the preparation of the gas. All except the smallest tents were flat oblong sheets of canvas, rounded at the corners and sewed with overlapping double seams. Seven of these were 50 × 60 feet in diameter, ten were 40 × 48 feet, and twenty were 32 × 38 feet. There were also ten conical tents eleven feet in diameter at the base, used for the smallest trees. For lifting these tents into place there were two 14-foot scantlings for the smaller sheet tents, two 20-foot lifts made of 2 × 4 scantlings, spliced and reinforced, and two 30-foot masts. Each pole when in use was fitted with a pulley, through which ran a three-fourths inch rope, and was also provided with from one to three guy-ropes with which to direct its motions as the tents were being lifted and drawn into place. For trees twelve feet in height, or less, one 14-foot pole was the most convenient lift. For those between twelve and eighteen feet one 20-foot pole was commonly used unless the top of the tree was unusually broad, when two were necessary. For still larger trees the 30-foot masts were used, one or both according to the size of the tree.

*Description of the Operation.*—The method of handling the tents and of liberating the gas was substantially the same as that described and amply illustrated in Professor Woodworth's Bulletin 122, already referred to (pp. 20–30). Different phases and variations of the operation are illustrated in Plates II.—VI. Attempts were made at first to fumigate very large trees, even when two tents of the largest size were necessary, one being drawn over the other so as to lap upon it several feet. (See Plate V.)

In ordinary work with one pole three men were required to handle the tent, but when two poles were used a fourth man was necessary. Two others were needed for the process of fumigation, making a squad of six for the entire operation.

For peach- and apple-trees of medium size, that is, 12 to 18 feet in height with a spread of 8 to 15 feet, a squad of three men with a single 20-foot lifting pole did the work most expeditiously. The pole was leaned against the tree on the side opposite that

from which the tent was to be raised, and one end of the rope running through the pulley at the top of the pole was thrown over the center of the tree and made fast to the nearest edge of the tent. The pole man then hauled the tent upward to the pulley, or at least high enough to clear the tree, and fastened his rope, took the guy-rope hanging from the top of the pole, moved forward far enough to get the necessary leverage and drew the tent over the tree, the other two men of the squad, one at each side of the tent, spreading it over the sides of the tree and adjusting it to the top. This operation is illustrated by Plate II., taken just as the men have begun to pull the tent forward over the tree. After the tent had been drawn forward far enough one tent man loosened the pulley rope and let the pole fall, the pole man detached the rope from the canvas and set the pole up at another tree, while the tent men ran a binding rope about the tent below the tree top, drew it closely, and tied the ends together. The borders of the tent were then laid close to the ground, and weighted with earth if high wind made this necessary, and the tent was carefully searched for possible leaks.

The fumigator prepared the charge according to the formula of the California Bulletin for winter treatment. He measured the circumference of the tent at its largest diameter and estimated the distance over the top from his knowledge of the length and width of the tent in use. The "acid man" measured the required amount of water and acid, poured them into the generator and held up the border of the tent while the fumigator put the generator in place near the trunk, charged it, and withdrew. He then quickly dropped the tent, seeing that it lay close to the earth, permitting no gas to escape.

The chemicals used were in the proportions indicated for a .3% gas in the table on page 28 of the California Bulletin. From the fact that the tent was usually drawn in below the head by a rope while the measurement was made round the top of the tree at its greatest diameter, the proportion of gas was in most cases considerably stronger than .3%. After charging the tent with the gas it was left to stand forty minutes, at the end of which time it was taken down and moved to another tree.

*Preliminary Operation at Monticello.*—Fumigation can be done while the leaves are on the trees only at night or on dark and cloudy days, and our first attempts being made in June (1899), the work was done entirely at night. The infested place nearest to my office and most convenient of access was Monticello, in Piatt county, where the San Jose scale had been found on a few town

lots containing various species of fruit and ornamental trees and shrubs.

A brief operation there demonstrated at once the impracticability of satisfactory fumigation work on the miscellaneous stock of an ordinary town lot. The trees infested were of various shapes and size, some of them too large to be inclosed by a tent. Trees, shrubs, and vines were often mingled in thicket-like masses which could not be covered securely, and the various kinds of vegetation which it was necessary to treat were variously sensitive to the withering action of the gas.

After one night's work of my field party on the grounds of a prominent citizen I was summoned by telegraph both by the foreman of the fumigating squad and by the owner of the premises, and experienced no small difficulty in re-establishing cordial relations between the parties concerned. To do a thorough piece of work some destruction of small shrubbery had been necessary, and the leaves of several kinds of vines and shrubs were badly withered by the gas.

An inspection made the following year, April 14, 1900, showed an unexpectedly favorable result. On one tree heavily coated with scales many living specimens were found under a crust of the dead, but elsewhere two hours' search disclosed but three living scales. The place had been temporarily saved from serious damage by the scale, but at a cost exceeding the value of the rescued property, and the failure to exterminate was evident. No attempt has since been made by me to treat miscellaneous trees and shrubs on town lots by the fumigation method.

The trees and shrubbery on twenty-one lots in this town—all on which the San Jose scale could be found—were sprayed with a twenty per cent. soap emulsion of kerosene April 10–19, 1900.

*Orchard Fumigation at Sparta.* — A region of more than twenty-five square miles about Sparta, in Randolph county, was known by me to be generally infested with the San Jose scale in the fall of 1899, this and the neighborhood of Richview, in an adjoining county, being the most important infested districts discovered in Illinois up to that time. After the completion of the the annual nursery inspection of 1899, preparations were made for a general campaign with the fumigation equipment in this neighborhood, and my party took the field at Sparta October 18 under the charge of Mr. E. C. Green, with Mr. R. W. Braucher as inspector. Here it continued actively at work for the next two months, by which time it was evident that with the appropriations available it was altogether impossible to treat the

infested premises of this region fully by the fumigation method, and the party was transferred to Richview, in Washington county, for work on another plan.

The Sparta district was mainly one of small farm orchards, of which only here and there one had expanded in a way to make its fruit an important part of the owner's crop. Many of the infested orchards were very old or contained some very old trees of a size to make fumigation exceedingly difficult or to put it altogether out of the question (Plate VII.). Taking one orchard with another, infested trees of every size were to be found, from those recently set out to giant survivors of the plantings of the early pioneers. The owners had often neglected their trees until it seemed a waste of public funds to attempt to save them when infested by the San Jose scale; but as the law gave me no power to condemn a tree until its value was altogether gone, I was obliged to treat such trees whether they were worth the cost of treatment or not. Osage orange hedges had become extensively infested by the scale in this district, in one instance at a distance of a quarter of a mile from the nearest orchard. Thickets of escaped fruit trees were growing beside the roads in fence corners, or by the borders of woods, and these were often more or less infested, and as the country still contained many remnants of its original forest covering there seemed a considerable probability that the scale was obscurely distributed far and wide through this forest growth.

Notwithstanding the discouraging features of the situation we made a serious attempt at fumigation here, which presently took the form, however, of a preliminary operation to show what was practicable by this method in such a place, and what must be otherwise provided for.

*General Results.*—From our experience at this place it soon became clear that local extermination of the scale was impracticable by fumigation, or by a single operation of any kind, unless power were given to destroy utterly everything infested which could not be cleared of the scale at once; that many of the trees were too large to fumigate, and hence could be treated only with a liquid spray; that the fumigation process in such a region was slow and extremely costly as compared with any other known; and that weather conditions often greatly diminished its efficiency by making it practically impossible to hold the gas under the tents at full strength long enough to produce the desired effect. In very windy weather no care in the management could prevent the rapid escape of the gas, as was shown by the strong smell of it on the leeward side of the tent and the absence of any such smell when

the tree was uncovered; and when the weather was very cold the watery vapor from the generators condensed on the canvas and immediately froze, lining the tents with ice. In this condition they were likely to break when folded in handling, and the brittle branches of the tree breaking when the heavy tent was hauled across the top, the tents were often torn by the jagged stubs.

Furthermore, it appeared from subsequent inspections that the cases were few in which all the scales on a tree appeared to be killed, and the frequency with which scales were found alive on the lower part of the trunk, while all were seemingly dead on the remainder of the tree, showed that the insecticide gas did not diffuse equally under the tent, but tended to rise, leaving near the ground a layer of insufficiently poisoned air. As this unequal diffusion of the gas has since been demonstrated in closed rooms, — a fact now taken into account in the construction of fumigation houses,—it is evident that we have here a serious objection to the whole process of orchard fumigation for the San Jose scale. We now know that peculiar methods and special precautions are necessary to secure an equal diffusion of the gas, even in the air-tight rooms used in nursery fumigation, and with the varied conditions and rapid work of orchard fumigation it is clearly impossible to secure a uniform action even in the average case.

*Details of the Work and its Results.*—The following items concerning thirteen representative orchards fumigated at Sparta are taken from the field reports of the foreman and inspector.

No. 1. On the place of Alvin Blair three hundred and ninety-five trees, most of them peach, were fumigated from October 20 to November 4. They were of medium size except a few of the apple-trees, which were very large, requiring the use of two of the largest tents lapped together over one tree and tied down with ropes. The peach-trees had been severely cut back the preceding spring previous to spraying with whale-oil soap (see Plate IX.), and the sharp stubs remaining punctured the tents, thus making necessary constant inspection and frequent repair of leaks. No doubt some gas escaped and some trees were imperfectly treated. A high wind was blowing when much of the work was done, and great embarrassment was also caused by cold and rainy weather, the tents tearing easily when wet and frozen. This place was inspected September 10 of the following year (1900), and badly infested peach-trees were found scattered through the orchard, the wood of two years' growth sometimes almost incrusted. In one row which was carefully examined the scale was found on seventy-three per cent. of the trees.

No. 2. On J. W. Robinson's place one hundred and seventy-seven trees, thirty-six grape-vines, and seven shrubs were fumigated October 18–20. This place had also been sprayed with whale-oil soap early in May of the same year to check the spread of the scale. September 10, 1900, twenty-seven trees were inspected, and scales were found on twenty-one. Two of these were very badly infested, but it was surmised that these had been left without treatment on the promise of the owner to destroy them as worthless.

No. 3. The place of Mrs. J. B. Hayer was probably the one first infested in this whole region, one orchard having been completely destroyed by the owner because of injury by the scale. The trees remaining were mainly apple and pear, most of them very badly infested. One hundred and seventy trees were fumigated here November 24–27, high winds causing considerable trouble. September 12 of the following year no badly infested trees were seen, but living scales were found on thirty per cent. of the trees.

No. 4. On the place of Jefferson Porch both peach- and apple-trees were badly infested. The fumigation squad was here from November 28 to December 2, treating eighty trees of medium size. September 11 of the following year living scales were found on fifty-three per cent. of the trees, but were numerous on none.

No. 5. On the place of J. K. Blair ninety-one peach-trees were fumigated November 6 and 8, some of these badly infested and others slightly so. Twenty-eight large old apple- and peach-trees were marked for removal. Those fumigated were planted so close together that they could be treated only with great difficulty, and the canvas was badly torn in the operation. The treatment proved, however, to be unusually effective, and living scales were found September 8, 1900, on only two of the trees. A plum-tree badly infested when fumigated appeared at this time to be entirely free of living scales.

No. 6. In an orchard of several acres belonging to Sylvester Brown most of the trees were infested, some of them badly so. Many of them were large, requiring two of the largest tents to cover them. Ninety-one trees were fumigated November 8–11, and thirty-five were marked for removal, eight of them large old apple-trees. September 10, 1900, but five infested trees could be found in this orchard, and on one of the old apple-trees badly infested the preceding year not a living scale could be detected.

No. 7. November 18–23, two hundred and twelve small to medium trees were fumigated on Mr. James Davidson's place, a few apple- and two pear-trees too large to be covered by tents be-

ing left for the spraying gang. September 11, 1900, living scales were found on four of these trees, but all the others were apparently clean.

No. 8. November 23 and 24, twenty-three trees were fumigated, together with a few grape-vines, on the place of Charles Lott. Although a strong north wind made the handling of the tents unusually difficult, no living scales could be found on this place September 11, 1900, except on one apple-tree left for removal by the owner as worthless, but which he had failed to destroy.

No. 9. December 4, 1899, seventy small trees were fumigated on William Wilson's place, thirty per cent. of which were found infested by a few living scales September 11 of the following year.

No. 10. On Thomas H. Wilson's place a few trees were reported infested in a six-acre orchard of apple and peach. One hundred and twenty-six trees were fumigated here December 4 and 5, and September 11 of the following year living scales were found on ninety per cent. of them. The wind was troublesome at this place, the canvas was stiff with ice and easily torn, and lumps of frozen earth were dug up to hold the bottom of the tent in place.

No. 11. A thirty-five-acre orchard of Thomas Brown's, in which a number of infested peach-trees were found along one side, was treated December 7–16, 348 trees being fumigated here in all. These ranged from six to twenty-five feet in height, the majority requiring tents of medium size. On the 14th of December a moist snow stopped the work, which was resumed the following day in snow about a foot deep. September 12, 1900, a few scales were found on five of the trees, but the others were seemingly clear.

No. 12. On the place of Frank Blair occupied by William Blair was a badly infested young orchard and two infested hedges near by. One hundred and eighty-five trees of medium size were fumigated here November 11–15. September 8 of the following year twenty-nine of these trees were critically examined, and sixteen were found very slightly infested. The bases of the trunks of some were, however, well stocked with living scales, and sprouts growing up from near the base had thus become heavily infested.

No. 13. On the place of James A. Wood sixty trees, some of them badly infested, were fumigated December 6, and one was cut down as worthless because of the scale. A few were very large, requiring two of the largest tents to cover them. September 11, 1900, four of these trees were still badly infested, and thirty-five per cent. of them showed more or less of the scale.

*Orchard Fumigation at Richview.*—With the transfer from Sparta to Richview the problem of local extermination was materi-

ally simplified. The latter town is in the midst of a typical fruit district. The orchards are large and mainly well kept; they are comparatively young and uniform and contain but few overgrown trees; the infested district was not hopelessly large; and the surroundings were not unfavorable to thorough work, the presence of Osage orange hedges being the most unfavorable feature.

With the advantage of two months of active field experience my party was prepared to do thorough and careful work at this place, and the instructions were to spare no labor or pains to kill every scale in every infested orchard. Hydrocyanic acid gas was used for all trees to which it was adapted, but the attempt to cover very large trees with tents was given up, such trees being severely pruned and thoroughly sprayed with kerosene emulsion diluted to contain twenty per cent. of the oil. (See Plate VIII.)

Great care was taken that the tents should be kept in perfect repair, and every part of the work was carried on under the immediate supervision of Mr. Green, foreman of the squad, or of Mr. Braucher, the inspector. The treatment was applied thoroughly, not only to all trees on which the scale could be found but to others near enough to stand in any danger of infestation. Owners of infested hedges were induced to destroy them (Plate IX.); trees very badly infested were, as a rule, cut out and burned; and, in short, nothing was omitted which would help to make the work effective and complete.

We had also at Richview the especial advantage of the countenance, aid, and influence of Mr. J. W. Stanton, Treasurer of the State Horticultural Society, himself an owner of large fruit farms, and a man whose character and experience made his judgment and advice acceptable to his entire neighborhood.

The work here began December 22, 1899, and continued to February 10, by which time all premises known to be infested had been treated, with the exception of one large apple orchard so far removed from any other fruit plantation that no danger was apprehended of an escape of the scale from it to any other property. A general inspection of this region was made after a lapse of two years, in March, 1902, all the places previously infested being then very carefully examined by Mr. R. W. Braucher, my most acute and experienced inspector.

*Details of the Richview Work.*—No. 1. The first place treated at Richview was an orchard of apples and peaches on the James Newcome Estate, owned at the time by J. W. Stanton and George McCoy. 2,087 trees of small to medium size were treated by fumigation between December 22 and January 4. On four of these

days—December 29 and 30 and January 1 and 2—the weather was extremely cold, and fires were kept burning in the orchards to keep the water from freezing. The canvas was so stiff with ice that it was easily torn, and it was difficult to bring the skirts of the tent so close to the ground as to prevent all leakage of gas. When the tents were removed from the trees, at the end of forty minutes, no odor of the gas was perceptible during this coldest weather, although at other times it was very distinct. This work was done under the constant personal supervision of either Mr. Braucher or Mr. Green.

March 6, 1902, many trees in this orchard were badly infested, and some of them were almost completely incrusted by the scale.

No. 2. In the apple orchard of Levi Walker, a few trees along one side were found infested and also an adjoining Osage orange hedge. This place was fumigated January 8 and 9, during a January thaw following upon two days of rain. January 8 mud and water were ankle deep in that part of the orchard where the work was done. The canvas became very heavy and five men were needed to handle the tents. One hundred and thirty-five trees were fumigated, ranging in height from twelve to twenty feet, and the infested Osage orange hedge was cut out about a month later. Forty-seven rods of high and heavy hedge were cut away, and the stumps were sprayed with strong kerosene emulsion.

March 7 to 12, 1902, this orchard and hedge were examined by Mr. Braucher. An occasional tree was found slighly infested with the scale in that part of the orchard fumigated two years before, and the hedge, which had grown up from the roots, was again badly infested.

No. 3. In a small orchard belonging to I. H. Jones forty-seven trees were fumigated January 10–12. One old peach-tree was destroyed, and two plum-trees were subsequently sprayed with kerosene emulsion. March 15, 1902, three trees on this place were found slightly infested with the scale.

No. 4. January 12, sixty apple- and pear-trees of medium size and smaller were fumigated in a small infested orchard belonging to Mr. James Ewing, many of them completely incrusted by the scale. March 14, 1902, only three infested trees could be found on this place, and the scale was scarce on these.

No. 5. In the orchard of George McCoy, composed of trees of medium size or larger, were a few slightly infested trees. All these were fumigated January 13, together with others around them for several rows in all directions, one hundred and thirty-

eight trees in all. Owing to the discovery of a single suspicious scale on an adjoining Osage orange hedge a considerable section of the hedge was destroyed February 10. March 6, 1902, the part of this orchard treated two years before had again become slightly infested, and the adjoining hedge was reported as in bad condition from the presence of the scale.

No. 6. The orchard of Jasper Wilgus was generally and variously infested, many of the trees being in rather bad condition. Two hundred and seventy-eight small to medium trees were fumigated here on the 15th and 16th of January, two hundred peach- and apple-trees were destroyed by the owner as worthless, and one hundred and sixty-one trees too large to fumigate were sprayed with twenty per cent. kerosene emulsion January 23–26. February 9, three rods of hedge infested by the scale were removed and destroyed. This place was inspected February 28 and March 14, 1902, at which time some of the trees in that part of the orchard which had been fumigated were again badly infested, as well as a considerable length of the Osage orange hedge. On the large trees which had been sprayed with kerosene, on the other hand, only a few scales could be found.

No. 7. In a small orchard on a town lot belonging to William Edwards forty-one trees were fumigated January 17, including several reported as infested. March 1, 1902, the scale could be found only on a single tree.

No. 8. In a small infested orchard belonging to Thomas Hoke forty-six badly infested trees were fumigated January 10 to 20, and fifteen were destroyed as worthless. March 1, 1902, thirty-five of the trees were re-examined, and thirty-two of them were generally infested by the scale to an extent to require another treatment without delay.

No. 9. January 27 one hundred and seventy-two peach- and apple-trees were fumigated in an infested orchard belonging to Mrs. E. A. Glenn, and eleven trees were sprayed with 20 per cent. kerosene emulsion. According to a report of an inspection of eighty-eight of the fumigated trees made February 28 and March 1, 1902, thirty-two of these were again infested to an extent to require speedy treatment as a protection to adjacent orchards in which the scale had not been found.

No. 10. On J. Bennett's place fifteen trees were fumigated January 17, and on February 2 one large apple-tree was sprayed with kerosene emulsion. March 1, 1902, two small trees slightly infested furnished the only remaining traces of the scale.

No. 11. One hundred and thirteen trees were fumigated Jan-

uary 20 and 22 in an infested orchard belonging to W. H. Grove; and February 2, sixty-seven trees additional were sprayed with a twenty per cent. emulsion of kerosene. March 1, 1902, twenty-nine of these orchard trees were found infested, and also a few peach sprouts along one side of the place.

No. 12. The pear and apple orchards of J. W. Stanton were somewhat infested at this time, although they had been extensively treated with insecticide sprays since the first discovery of the scale on his premises three years before. Seven hundred and seventeen apple-trees in one corner of an infested orchard were fumigated January 22–25, and about thirty large peach-trees were removed. January 27-29 nine hundred dwarf pears were sprayed with kerosene emulsion, a part of it containing twenty per cent. of kerosene, and the remainder, by mistake of an assistant, fifty per cent. With this latter strength over one hundred trees were treated. Two years later, February 28 and March 4 and 5, 1902, all these orchards were critically examined and only a few scattering scales were found. The trees treated with a fifty per cent. emulsion had not been injured in the least. It should be said that this orchard was in excellent condition, its owner being an experienced and careful fruit grower, and everything was consequently favorable to effective work.

No. 13. January 25 and 26 thirty-five large trees were fumigated in an infested orchard of apple and peach belonging to S. Newcome. March 15, 1902, Inspector Braucher reported that eighteen trees were slightly infested, but less so than two years before.

No. 14. Nineteen trees were fumigated January 26 in an infested apple orchard belonging to Edward Aplin, and some peach-trees were destroyed at the owner's request. March 14, 1902, a few slightly infested trees were found.

No. 15. January 26 nineteen trees were fumigated on Mrs. R. R. S. Vasey's place, and February 6 one very large tree was sprayed with kerosene emulsion. March 14, 1902, three slightly infested trees were found by my inspector on these premises.

No. 16. On Dr. W. Smeaton's place, in charge of L. D. Allen, sixty-seven trees, mostly peach and some of them badly infested, were fumigated January 27. This place was inspected March 12, 1902, and a few trees found slightly infested. A hedge on the place was now infested and required treatment.

No. 17. January 26 an infested tree on the place of Mrs. Simeon Shinall was fumigated, but an inspection of it March 15, 1902, showed it to be slightly infested.

*Comment on the above Results.*—The foregoing statements of conditions found at Sparta and at Richview are not strictly comparable with each other because the inspection at Sparta was made in September, 1900, eight or nine months after the insecticide treatment, and that at Richview was made in February and March, 1902. The Sparta region was inspected in the midst of the first growing season after the trees were treated and before the time of most rapid multiplication of the scale,—which is usually the month of October in southern Illinois,—while the Richview inspection was made after a lapse of two complete seasons of growth and multiplication.

The best results of orchard fumigation obtained by my parties are shown by the inspection reports on places 5, 6, 7, and 8 in the Sparta district, and 3, 4, 7, and 12 at Richview. In the four Sparta orchards, where 317 trees were sprayed in the fall of 1899, the scale could be found on only 11 of them in September, 1900; and in the first three Richview orchards, where 148 trees were treated, only seven proved to be infested two years later. At Sparta No. 8 a close approximation seems to have been made to a complete extermination of the scale and the same may be said of Richview No. 7, and perhaps, also, of No. 12.

The most serious obstacle to work was that offered by cold and freezing weather, as is shown especially by No. 10 at Sparta and No. 1 at Richview. High winds were less disadvantageous (see Nos. 3 and 8 of the Sparta district), and excellent results may be obtained in spite of them, as shown especially by No. 8. Neither snow nor wet weather diminished noticeably the effectiveness of the operation, as shown by No. 11 at Sparta and No. 2 at Richview. It would appear from Sparta No. 6 that large trees can be fumigated effectively by the use of two tents at once, overlapping by their edges.

In none of the cases here described was even a single orchard completely cleared of the scale,—unless possibly at Sparta No. 7,—a fact which taken in connection with the costliness of fumigation as compared with other equally if not more effective methods puts it completely out of the field for ordinary orchard work in Illinois.

## Cost of Orchard Fumigation.

The expenses of our work are divisible roughly into those for exploration and inspection of the infested territory, for equipment, for transportation of the outfit and party from place to place, for supervision and general management, and for the operation of fumigation itself. All except the last of these were so largely

special to our undertaking and so little like those of the ordinary owner of an orchard that they would be of little or no practical interest. For the great variety of trees on which we had to work in fumigating everything in an extensive district, we needed a greater variety and a larger number of tents than would usually be necessary in private work, and the cost of extensive inspection and that of transportation would be avoided by the orchardist working only on his own premises. The expenses of actual fumigation, however, would be about the same ordinarily as in our work, provided that the private owner had to hire all his labor but made no charge for his own services, and this item of our account will consequently be useful for comparison. It must be remembered, as explained elsewhere, that the necessity we were under to keep the party at work in good weather and bad, whenever work was at all possible, increased the average cost of fumigation per tree above what it would have been if our men could have been laid by in bad weather without expense, or could have been otherwise profitably employed.

At Sparta 2,297 trees were fumigated on seventeen different premises—an average of 135 trees at each place. 1,160 lbs. of cyanide of potassium and 290 gallons of common sulphuric acid were used in this work, at a cost of $412; and 1,700 hours of labor were required, at 10 cents an hour. The total expense was $582—an average of 25 cents a tree.

At Richview, where the trees were smaller and conditions were more favorable generally, 3,879 trees were fumigated on seventeen different places, an average of 228 trees on each. 994 lbs. of cyanide of potassium and 248 gallons of sulphuric acid were used, at a cost of $353; and the bill for labor was $113 for 1,130 hours—an average, all told, of 12 cents a tree.

Taking both places together, the cost of the mere fumigation of 6,176 trees was $1,048, or approximately 17 cents a tree. Comparisons of effectiveness and cost by this and other methods will be made later in this article, after a detail and discussion of the results of the use of the fluid insecticides.

### Treatment with Whale-oil Soap.

Our experience in the treatment of many thousand trees with this well-known insecticide, prepared in the usual strength of two pounds to the gallon of water, has merely served to confirm the common conclusions with respect to it. It has proved to be very efficient for the destruction of the scale, killing practically all reached by it; has done no injury to trees or shrubs; but has

proven dangerous to the fruit buds of the peach unless applied in spring after the buds begin to swell. It is much the most expensive of the sprays of which we have made use, costing at the rate of $6.50 per hundred gallons, and has also been the most inconvenient of application in cold weather. This solution is only fluid while warm, becoming of a semi-gelatinous consistency when entirely cool, and if, owing to the clogging of the nozzle, it was necessary to stop its flow for a little time, the delivery hose was sure to clog and fill if the weather was much below freezing. Our work was all done with potash soaps, but I have made no comparative tests of these and soda soaps, and have failed to find any published evidence in support of the very common preference of the former as an insecticide.

### Experience with Kerosene Emulsion.

The heavy cost of the whale-oil soap solution, the annoyance and delay caused by its clogging in the delivery hose in very cold weather, and the practical certainty that a large proportion, if not all, of the fruit buds of peach-trees sprayed with it would be killed except in the comparatively small number of cases where our treatment could be applied in spring, led to the substitution for it during the winter of 1899 and 1900 of an emulsion of kerosene diluted with water and varying in actual practice to contain from 20 to 25 per cent. of kerosene.

Beginning at Sparta and Richview in January, 1900, its use was continued through February and March at Carterville and Albion, and at Monticello until April 19, by which time the season was too far advanced to permit further use of this winter spray without injury to the unfolding leaves. 5,315 trees were sprayed with it in these places and at this time. November 8 of this same year insecticide work was begun at Quincy, where a 25 per cent. kerosene emulsion was used on one large and three small orchards November 14 to December 19, and a 20 per cent. emulsion on another at New Boston, in Mercer county, December 29–31. At Barry, in Pike county, an apple orchard of 500 trees was sprayed with it, partly as an experiment, January 7–14, 1901. The mixture used there was in three different strengths, containing 20 per cent., 25 per cent., and 40 per cent. of kerosene respectively.

The orchard insecticide work of the fall of 1901 began November 25, and at first a 25 per cent. emulsion of kerosene was used for everything. December 9, however, instructions were issued to spray all peach- and plum-trees with the so-called California wash of lime, sulphur, and salt, and to use the kerosene emulsion for

other trees only on sunny days, substituting whale-oil soap for it whenever the weather was dark. Finally, on February 5, 1902, my chief inspector, Mr. Green, was directed to stop the use of kerosene altogether, and to dispose of his stock on hand. This order was made in consequence of a report by Mr. Braucher, then engaged in inspecting orchards which had been treated by us in the fall and winter of the preceding year, to the effect that apple-trees had apparently been injured in November of that year in the New Boston orchard mentioned above by a 20 per cent. emulsion applied by Mr. Green.

*Kerosene Emulsion at Richview.*—The operations at Richview in 1900 fairly represent the cost and the results. One thousand five hundred and thirty-five trees were treated at this place at an expense of $17.65 for oil, $37.65 for labor at ten cents an hour, and $16.73 for the hire of a horse—a total of $72.03, or an average of somewhat less than five cents a tree.* The results reported cannot be readily summarized and are consequently given in detail for several typical lots of trees.

No. 1. One hundred and fifteen apple-, pear-, and peach-trees, most of them large and old, treated with 20 per cent. emulsion January 26–29 and February 1, 1900, on the premises of Mr. G. T. Hoke—two town lots and an old orchard near by. October 8, 1900, a few living scales were found on some of the peach-trees that had been sprayed. March 11, 1902, the trees on the town lots were slightly infested, and a few scales were found on some of the orchard trees.

No. 2. Nine trees on a town lot belonging to Mr. K. Mark were treated February 1, 1900. March 11, 1902, 5 of the 9 trees were slightly infested.

No. 3. Twenty infested trees varying from medium to large belonging to Mr. Charles Miller were sprayed February 1 and 2, 1900, and March 11, 1902, scales were found on only one of these trees.

No. 4. Twelve badly infested peach-trees, small to medium in size, sprayed February 3, 1900, were found generally infested, but not heavily so, on March 22, 1902.

No. 5. Of 36 infested peach-trees belonging to Mr. John Gay, treated February 23, 1900, 20 were found infested March 3, 1902.

*The average cost of spraying 5,710 trees, from January, 1900, to January, 1901, at five different localities was 4½ cents a tree. The premises treated were mainly town lots, requiring frequent interruption of operations and consequently increased expense. In three orchards near Barry 1,486 trees were sprayed, and at a cost of 3.2 cents per tree.

No. 6. February 3–6, 1900, 4 infested trees on a town lot belonging to Mr. N. F. Tate, and a large pear-tree also infested on another lot, were sprayed with 20 per cent. emulsion. A large apple-tree was destroyed at this time as practically worthless from the abundance of the scale. Two years later, March 13, 1902, all 5 of the trees sprayed were slightly infested, as were also sprouts from the root of the apple-tree destroyed.

No. 7. February 6, 1900, 12 orchard trees belonging to Mr. C. P. Cooper were sprayed, and March 12, 1902, two years later, the scale was found on 2 of these trees.

No. 8. Three large peach-trees in an orchard of Mrs. M. A. Robins were sprayed February 6, 1900, and March 17, 1902, two years later, 2 of the 3 were slightly infested.

Similar data are given for seven other premises, all pointing to the conclusion that trees were rarely cleared of the scale completely by this insecticide spray, but that a single treatment would serve as an efficient protection for at least two years. In several of these cases another insecticide treatment would be necessary by the end of another year at the farthest. No injury to trees of any kind was done by this twenty per cent. emulsion distributed at Richview in January and February of this year.

*Experience at Carterville, Albion, and Monticello, Spring of 1900.*—Beginning with March 5 and continuing to March 17, 2,272 trees, belonging to six owners, at Carterville were sprayed with a twenty per cent. emulsion with Mr. Green in charge. These trees were of mixed kinds, mainly apple, but including also plum, pear, and peach. Subsequent visits made in 1901 and 1902 showed that no injury whatever was done to any of these trees.

At Albion 674 trees were treated, mostly peach but with some apple, plum, and pear, all receiving a twenty per cent. emulsion between March 23 and 29. These trees were scattered in small lots upon twenty-four town premises. This place was repeatedly visited by inspectors and spraying parties up to the winter of 1902, and no trace of injury by the kerosene treatment was discovered.

Essentially the same statement may be made with respect to Monticello, where 843 fruit trees of various kinds, including apple, peach, and plum, were sprayed on twenty-two premises from April 10 to 19, no appreciable injury following.

*Experiment with Kerosene Emulsion at Barry.*—The only strict experiment with this spray made by us in the winter of 1901 was the last operation of the season—that in the apple orchard of Belah Wright, at Barry, Pike county. Five hundred trees were treated here January 7–14, 150 of them with 20 per cent. emulsion,

223 with a 25 per cent., and 127 at a strength of 40 per cent. January 7 and 8, when the 20 and 25 per cent. mixtures were applied, the weather was cloudy and rather warm. January 9 a sleety rain fell, covering the trees with ice which continued until January 14, when the 40 per cent. mixture was applied. This was a clear day with no wind.

Regarding this as an experimental test of the effects of the soap emulsion of kerosene, both on the scale and on the tree, I sent Mr. Braucher for an inspection of this orchard October 2, 1901, before beginning the fall work of the season. A general view of the orchard showed that the treatment as a whole had been very effective, but that more scales had survived in that section of the orchard treated with the 20 per cent. emulsion than in either of the other two. Two trees were found, in fact, in this part which were regarded as badly infested, and on several others scattering scales were seen. None of the trees had been noticeably injured even by the strongest spray, if exception be made of a small spot of deadened bark on a single tree which might possibly have been due to it. In the section treated with 40 per cent. of kerosene scarcely a scale escaped, and even where 25 per cent. was used the treatment was very effective.

*At New Boston.*—December 22, 1900, in an orchard belonging to W. Esley, near New Boston, in Mercer county, both apple- and peach-trees were found generally infested, some of the former being practically incrusted. December 24–28 this orchard was pruned and prepared for spraying by Mr. Green. December 29 and 31, 239 trees were treated with a 20 per cent. emulsion of kerosene, the 29th being very cold, clear, and bright, and the 31st cold and dull. Part of the peach-trees were pruned as a preparation for treatment and were then thoroughly sprayed, but another lot of peaches, not known to be infested, were pruned slightly or not at all previous to the insecticide spray. January 17, 1902, an inspection by Mr. Braucher showed that ten of the thirteen small peach-trees which had been pruned were dead and another badly injured, while the adjacent lot, not pruned, were not reported as injured at all. Of the 75 young apple-trees generally and badly infested which had been treated December 29, 20 were dead and 10 were badly injured, and on 26 there were still small numbers of living scales. Ten-year-old apple-trees sprayed December 31 were not injured, neither were cherry, pear, and plum sprayed at the same time.

No explanation of this extraordinary occurrence can be suggested. The oil, although bought locally, was said to be of the same brand and grade as that used elsewhere without injury, and

the treatment was not peculiar in any discernible particular. On this account, even more than if a satisfactory explanation were forthcoming, the occurrence suggested caution in the use of the kerosene emulsion, and Mr. Braucher's report was followed at once, as already stated, by orders to substitute whale-oil soap for the emulsion in all our field work.

*Kerosene Emulsion at Quincy.*—Two other cases of apparent injury to trees by kerosene emulsion occurred in the fall of 1900 at Quincy.

No. 1. In an orchard mainly of peach-trees, belonging to Mr. Gustav Klarner, 7 trees were found October 3, 1900, infested with the San Jose scale, and were destroyed with the owner's consent November 8. Mr. Klarner wished to be sure that no scale remained on his place, and in view of the probability that other trees in the orchard were obscurely infested Mr. Green proceeded to spray all the trees, 997 in number, near enough those infested to endanger them in the least. After pruning them carefully as a means of securing a thorough distribution of the spray, he began the treatment November 14 with an emulsion containing 23 per cent. of kerosene.

The weather was unusually variable, but not cold at any time. The first day of the operation was cloudy and dull, and the second, November 15, was sunny and bright. Nothing was done on the 16th, 17th, 18th, or 20th because of rains, and only a little on the 19th, which was a damp and misty day. Spraying was resumed on the 21st and continued until the 23d, the first two of these days being bright and the last one dull.

There was nothing uncommon in this operation except that the brand of oil, purchased in the local market, was different from that ordinarily used by us elsewhere, and the emulsion was also a little stronger than the usual 20 per cent.

This orchard was inspected by Mr. Braucher between January 20 and February 17, 1902, that is fifteen months after treatment, but by this time extensive changes had been made in it by the owner, who had replaced many trees said to have been injured or killed, and had dug out a part of a large block, planting the ground to raspberries. In the part still standing 324 trees were either wanting or had been replaced by others the preceding spring. Mr. Klarner himself estimated his loss at 700 peach-trees.

No. 2. On the premises of Wm. C. Burgdorf, near Quincy, were scattered plots of mixed fruit-trees,—pear, peach, cherry, and apple,—among which Mr. Green found November 10, 1900, trees infested with the San Jose scale. Two small blocks of eighteen-

year old peach-trees, 196 in all, were grubbed out by the owner of his own accord between November 12 and 21, and 248 fruit trees remaining were sprayed by Mr. Green with twenty-five per cent. kerosene emulsion November 30 and December 3. The weather was bright, with little or no wind. February 18 and 19, 1902, Mr. Braucher found that the trees treated in this orchard were either killed or injured, the peach having suffered worst. Injury to the cherry is also especially mentioned. Four or five of these trees had been grubbed out, and some others were nearly dead. The San Jose scale was detected at this time on ten peach-trees, all in one lot which had been sprayed by Mr. Green.

No. 3. On the place of August Burgdorf, at Quincy, was an orchard of fifteen-year-old apple-trees which, because of its close proximity to a badly infested tree belonging to a neighbor, Mr. Green regarded as probably infested. Thirty-six of these trees nearest the infested tree were sprayed by him with a 25 per cent. emulsion December 4—a fair day with a light breeze—together with four other trees near by. February 18, 1902, this apple orchard was found by Mr. Braucher uninjured and apparently free from the scale, but two trees in an adjacent lot which had not been sprayed were at this time slightly infested.

No. 4. On Mr. Henry Hoffmeister's place, near Quincy, H. O. Woodworth found November 30, 1899, two apple-trees infested by the San Jose scale, and in November, 1900, Mr. Green reported three apple-trees badly infested and several peach-trees slightly so. These apple-trees and a few of the peach-trees were taken out by the owner and all the remainder were pruned by him preparatory to the application of the spray. In Mr. Green's judgment, as expressed at the time, this pruning was too severe and not according to his instructions, which he had illustrated by the sample pruning of a single tree. An emulsion containing twenty-six per cent. of kerosene was used on this place by Mr. Green December 17 to 19, the weather of the first day being dull and that of the other two days bright and fair. February 15, 1902, the trees on this place were in good condition according to Mr. Braucher's report, except for some apparent injury by the spray. It was said, however, by the tenant in charge that some of the trees sprayed had died and had been taken out.

All the orchards on the two places just described were sprayed with the same oil as that used on Mr. Klarner's place (No. 1), and the general remarks made concerning that place apply also to these.

### Kerosene Emulsion. Season of 1901–02.

The fact has already been mentioned that from November 25, 1901, to December 9 of the same year a soap emulsion containing 25 per cent. of kerosene was used by our spraying parties on everything treated by them, and that from December 9 to February 5 it was applied to all trees but peach and plum, these being treated with the California wash. At the latter date its use was wholly abandoned and whale-oil soap was substituted for it, this and the California wash being the only insecticides applied during the remainder of the season.

The emulsion was used within this period on 6,536 trees at 14 different places in central and southern Illinois. The largest use of it was made at Makanda and Carterville, where it was applied to 1,975 and 1,770 trees respectively. August 15 and 16, 1902, Mr. Titus visited these two localities under instructions to look carefully into the condition of the trees which had been treated with this kerosene spray, and according to his report no damage had been done at either place to trees of any description, while the effect on the scale was very satisfactory.

January 6–9, 1902, about 700 trees belonging to Dr. H. V. Ferrell, of Carterville, mainly apple but some of them cherry and pear, were treated with a 25 per cent. emulsion, and 130 trees, all apple but one—which was a pear tree—were sprayed at the same time on the place of Mr. J. W. Ghent. August 15, no injury from spraying could be detected in these orchards, which bore a crop of apples equal to the average crop of uninfested orchards in the neighborhood.

At Makanda 450 trees belonging to S. Y. Dickinson, mainly apple with a few cherry and plum, received the same kerosene treatment December 11–28, 1901. The apple orchard was on a steep clay slope and appeared to have suffered considerably from the drought of the preceding year, but there was no tangible evidence Aug. 16 of any injury due to the insecticide treatment applied.

On the place of Lammer Brothers, about 225 apple- and pear-trees were treated December 31 with a 25 per cent. emulsion, and owing to some apprehension of injury on the part of the owners this place was very thoroughly examined by Mr. Titus August 16. The trees were absolutely uninjured, as were also 530 apple-trees belonging to Mr. S. A. Carr, treated in the same way and examined at the same time.

Indeed the only injury done to trees by kerosene during the winter of 1901–02 of which I have been able to learn, was that to peaches on the place of Mr. Henry Archer, near Beamington,

Sangamon county. A mixed orchard of 513 trees was sprayed here November 29 to December 4 with a 23 per cent. emulsion of kerosene. The orchard was variously composed of young and old trees, and included apple, pear, plum, peach, cherry and quince. The young trees sprayed—peach, cherry, and pear—were wholly uninjured, but certain old peach-trees were, with few exceptions, dead by July 12, when the place was inspected at my direction by one of my nursery inspectors, Dr. W. C. Bagley. From his report it appears that the young orchard above mentioned had been cultivated the preceding year, but that the old orchard in which the dead peach-trees stood had received but little care, not having been cultivated for several years, and that the trees of various kinds remaining in it, both those which had not been sprayed and those which had survived the treatment, were in poor and unthrifty condition. The weather of the days during which the older peach-trees were sprayed was somewhat unfavorable, with fogs, mists, and cloudy sky. No harm was done to apple or quince. A few of the pear-trees had died after being sprayed, but as the blight was prevalent on the place, their death was probably due to that disease.

An apple orchard belonging to Mr. I. N. Lowe, near Auburn, in Sangamon county, sprayed with a 25 per cent. emulsion showed no sign of injury on the 12th of the following July, and a few peach-trees on these premises treated in the same way and at the same time were also unharmed.

### Field Use of the Lime, Salt, and Sulphur Wash.

From December 9, 1901, to April 15, 1902, all peach-trees receiving insecticide treatment by my field parties were sprayed with few exceptions with a mixture of lime, sulphur, and salt, known as the "California wash," and as a matter of convenience in spraying mixed orchards, some trees of other kinds received the same treatment. This wash was used on 433 different premises in 13 infested districts, but owing to occasional deficiencies in detail in operators' reports the total number of trees to which it was applied cannot be precisely given. Separate mention is made of its use, however, on 4,976 peach-trees, 463 plum, 586 apple, 111 pear, 31 quince, and various other kinds sufficient to bring the distinguishable total up to 9,000 trees.

During this period of four months of southern Illinois winter, the weather was, of course, widely various. The season was, as a whole, rather unusually favorable to insecticide work, but rains, sleets, snows, and freezing weather came frequently enough to test

quite fully the general effect of the weather on the efficiency of the insecticide. Although no exact account of the results over all the great area treated can now be given, a general statement may be made that the effect has been excellent and entirely satisfactory so far as I now can judge.

To secure an exact basis for a general judgment of the outcome I sent Mr. Titus in August, 1902, to examine orchards treated with this wash the previous winter and spring, and I have his report of the results of an inspection of 25 orchards in four different localities,—Summerfield, Makanda, Albion, and Browns,—and of many town lots at the first and last of these places. Although these localities inspected formed but a small part of the number treated, they constitute a larger and more varied experiment with this wash than has hitherto been attempted anywhere east of the Pacific region, and a report of results will no doubt be appreciated at this time.

Formulæ for the California wash have varied considerably in the literature of the subject, and as it is possible that conflicting statements concerning its value may be due in part to these variations in composition, the following description of the wash used during the winter in Illinois will have its value in this connection. The mixture was made as follows: Fifteen pounds of stone lime were slaked in a kettle over a fire; fifteen pounds of sulphur were sifted or stirred in as the lime was slaking, these materials being boiled vigorously until the lime and sulphur were entirely dissolved —usually something over an hour; and fifteen pounds of salt were then put in and the whole was boiled a quarter of an hour longer. Enough hot water was added to make fifty gallons, and the mixture was sprayed while warm through a nozzle with a large cap for a coarse spray. When the material first dried on the tree it gave the bark a saffron-yellow color, which changed in twenty-four hours to a dull green and then gradually faded to a greenish gray.

*The California Wash at Summerfield.*—No. 1. One hundred and forty-five peach-, plum-, and pear-trees sprayed on the place of Wm. Hagemann between March 29 and April 2. Practically all of these trees were badly infested with the scale. On the 29th of March the weather was clear at first, with the temperature ranging from 48 to 66 degrees, but a hard rain fell in the afternoon with a light northwest wind. From March 31 to April 2 the weather was continuously cloudy but there was no rain; the wind, northwest and west, from brisk to high; and the temperature ranged from 36 to 62 degrees.

August 16 several peach- and pear-trees were examined on this place and one thousand scales were carefully examined, pains being taken, as in all other cases on this trip, to select the scales from all parts of the tree. Not a living scale was found on this place.

No. 2. Twenty-three slightly infested peach-trees sprayed March 22 and 24 in the orchard of Messrs. B. and A. Baer. The weather was clear on the first of these days but cloudy the second, the temperature ranging from 42 to 72 degrees. August 16 no living scales could be found.

No. 3. Twenty-four badly infested peach-trees belonging to Mrs. Mary Reibold treated the 15th and 18th of March, the first day cloudy throughout with a temperature ranging from 54 to 62 degrees, the wind at first south, changing to northwest at four o'clock, rain from noon onward. March 18, clear all day and cool, temperature from 20 to 34 degrees, with light wind. August 20, no living scale to be found.

No. 4. Eighty peach- and plum-trees on the premises of Daniel Krehbiel sprayed March 6–8 and 14–15. The weather was cloudy on all these days, and rain began on the afternoon of the last. Three thousand specimens of the scale examined August 20 and but two found alive, both partly grown. They had evidently come from an infested hedge in close proximity.

No. 5. On several town lots belonging to Mr. John Eicher 17 trees were sprayed with lime, sulphur, and salt March 10, and August 20 no living scales could be found.

No. 6. Forty trees were sprayed, a part of them with lime, sulphur, and salt, on the town property of Thomas Keith March 10. August 20 no living scale could be found.

*The California Wash at Makanda.*—No. 1. On the place of Mr. S. A. Carr, near Makanda, 457 peach-trees were sprayed with lime, sulphur, and salt late in December, beginning with the 24th. The weather was very bad—cold, with much sleet. August 16 living scale could be found on these trees.

No. 2. On the place of Mr. S. Y. Dickerson, 1,743 trees treated with lime, sulphur, and salt at intervals throughout the season from January 2 to March 10 appeared wholly free from living scale August 16. In addition to a general inspection of these trees 2,000 scales were critically examined and none found alive.

No. 3. Thirty-three peach-trees were treated December 31 with the California wash in the orchard of Lammer Brothers, near Makanda, the weather being clear and the temperature about 40

degrees. August 16 no scales were found alive in this orchard where, besides a general inspection, 2,000 were examined critically.

No. 4. On the place of J. W. and J. E. Herrn 140 peach- and plum-trees sprayed with the California wash March 19 and 20, weather partly cloudy but without rain, thermometer 40 to 50 degrees. August 16 no living scale could be found.

No. 5. In the orchard of J. S. Springer about 190 peach- and plum-trees sprayed with lime, sulphur, and salt at various dates in January, February, and March. Four thousand scales critically examined by Mr. Titus August 16, but none found alive.

No. 6. One hundred and sixty-two peach-trees and seven plums treated March 24 to April 4 on the premises of W. H. Lipe. Sky cloudy throughout but no rain. No living scales found August 16 by general inspection or on a critical examination of 500 specimens.

All the orchards treated by my parties in this section were found in fine condition, although some of the worst infested trees had been lately attacked by the bark-borer, *Scolytus rugulosus*—an occurrence to be attributed to the diminished vitality of the trees due to the San Jose scale.

*The California Wash at Albion.*—No. 1. One hundred and fifty-seven peach-trees treated with lime, sulphur, and salt in the orchard of Hodgson Brothers, near Albion, April 5–15, the weather clear throughout. The buds were unfolding at this time, and the work was suspended at the latest date on account of the appearance of the leaves. August 21 the peach-trees sprayed were inspected, but no living scale could be found. Of a thousand scales examined none were alive.

No. 2. In the orchard of Mr. F. A. Kenyon 225 medium-sized peach-trees were sprayed March 18 to April 2. Two thousand specimens examined August 21 and two of them alive. No other living scales seen in this orchard.

No. 3. On the town lots of Anna C. Ferriman 23 peach-trees and 4 plums were sprayed April 7 and 8, the weather being fair. August 21 no living scale was found.

No. 4. On the town lots of Samuel Churchill (administrator) 37 peach-trees and 12 plums were sprayed April 5 and 7, the weather clear except for rain beginning at 3 o'clock p. m. on the 5th. Five hundred scales critically examined August 21 and no living ones found.

*The California Wash at Browns.*—No. 1. Three hundred and five peach-trees sprayed February 10–14 on the place of Atkinson Taylor, the weather being variable, with snow all day on the 10th

and on the evening of the 11th. Four thousand scales examined August 21 and 22 on the peach-trees sprayed and none found alive.

No. 2. In the orchard of George Briggs 22 peach-trees treated with lime, sulphur, and salt February 1–5, the weather cloudy throughout. One thousand scales examined August 21 and none found alive.

No. 3. Eighty-nine peach-, apple-, pear-, and plum-trees, but mainly the first, sprayed with lime, sulphur, and salt February 25 to March 4. These trees were very large and badly infested. The weather was clear throughout except on the 4th, which was cloudy without rain. Aug. 22 no living scales could be found on the peach.

No. 4. Thirteen peach-trees sprayed with lime, sulphur, and salt on the town lot of Mary E. Marriott February 6, the weather being clear. Five hundred scales examined and three found alive. These were armored specimens, the only ones found alive at this place, although several town premises besides those mentioned above were carefully inspected.

3,931 trees in all had been sprayed with the California wash by my field parties on the premises inspected by Mr. Titus in August. Besides making a careful general examination of these trees and finding no living scales he critically scrutinized, one by one, 21,500 individuals and found but seven of them alive. There were no crawling young, and none of these living scales had reached the age of reproduction.

## General Summary.

Four insecticides have been extensively used as winter applications for the San Jose scale in our general orchard work of the past three years in Illinois; hydrocyanic acid gas, whale-oil soap, kerosene emulsion, and the California wash of lime, sulphur, and salt, the first being applied by fumigation and the others as liquid sprays.

All are efficient destroyers of the scale under favorable conditions, but the operation of fumigation is practically restricted to comparatively small trees and to comparatively mild and quiet weather. The California wash has an evident advantage in persistence of effect, which amounts to an appreciable protection of the tree against immediate reinfestation.

These four insecticides differ materially in safety, in cost, and in convenience of application. Fumigation with hydrocyanic acid gas and spraying with the California wash are perfectly safe to all trees and shrubs if applied after the old leaves have fallen and before the young leaves have put forth; whale-oil soap is likely

to destroy the fruit buds of the peach if used before these have begun to swell in spring; and the kerosene emulsion in strength sufficient to insure the destruction of the scale is uncertain in its action on the more delicate kinds of trees,—the peach especially,—and on those of any kind which are in poor condition. Serious injury has occasionally been done to the peach, and in one case to apple, by an emulsion containing only 20 per cent. of kerosene, which is rather below the minimum strength at which this mixture should be used for the destruction of the scale. A twenty-five per cent. emulsion, on the other hand, is usually harmless to the apple and pear, but has proved in our work to be highly dangerous to the peach.

The cost of insecticide treatment includes the expense of the original equipment, that of the materials consumed, and that of the preparation and application of the insecticide. In respect to cost of equipment fumigation is by far the most expensive, especially if the trees to be treated are large, but the three insecticide sprays are prepared and applied by the aid of practically the same apparatus.

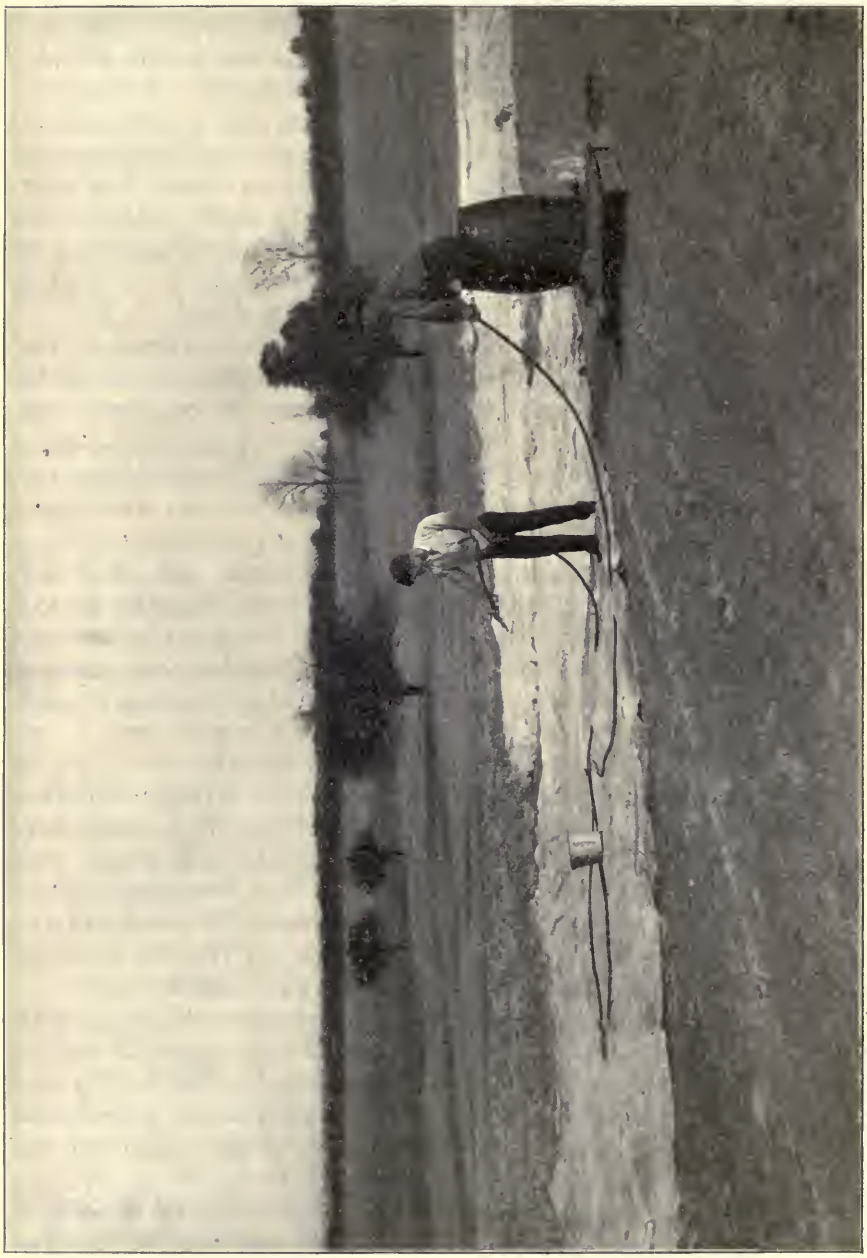
The cost of preparation and application is not materially different for the four insecticides under discussion, and will at any rate vary greatly in practice according to individual circumstances.

With respect to cost of materials, the fumigation process is much the most expensive. At Richview, where the trees treated were usually of medium size or less, the cost was nine cents a tree for fumigation materials, while at Sparta, where the trees averaged much larger, this cost was eighteen cents a tree. At the latter place whale-oil soap, although applied only to the largest trees as a rule, was used at a cost of seven cents a tree for the soap itself. At Carterville and Browns the average cost of lime, salt, and sulphur for the California wash was two to three cents, according to the size of the trees, while the general average per tree for kerosene emulsion as applied to over 5,000 trees was two cents each.

In convenience of application the preference belongs clearly to the kerosene emulsion and the California wash, the use of whale-oil soap being frequently embarrassed in very cold weather by the solidifying of the solution in the hose if the flow is stopped, and the operation of fumigation being a laborious and complicated one for trees above medium size.

It follows from the foregoing that of these various insecticide methods and materials the best for common use against the San Jose scale is spraying in winter with the California wash.

PLATE I.



OILING CANVAS FOR FUMIGATION.

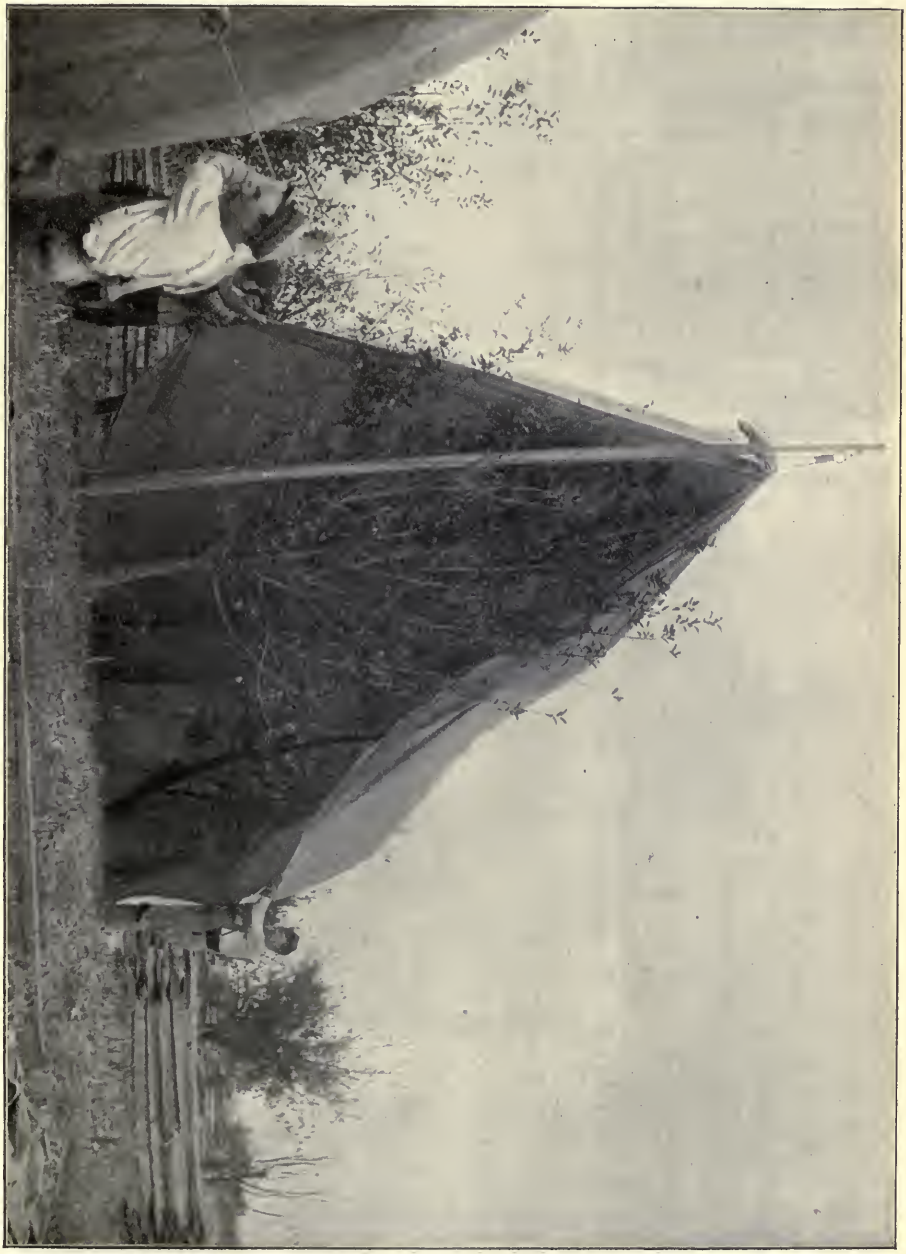


PLATE II.

SHIFTING FUMIGATION TENT WITH ONE POLE.

PLATE III.

SHIFTING FUMIGATION TENT WITH TWO POLES IN A SNOW-STORM.

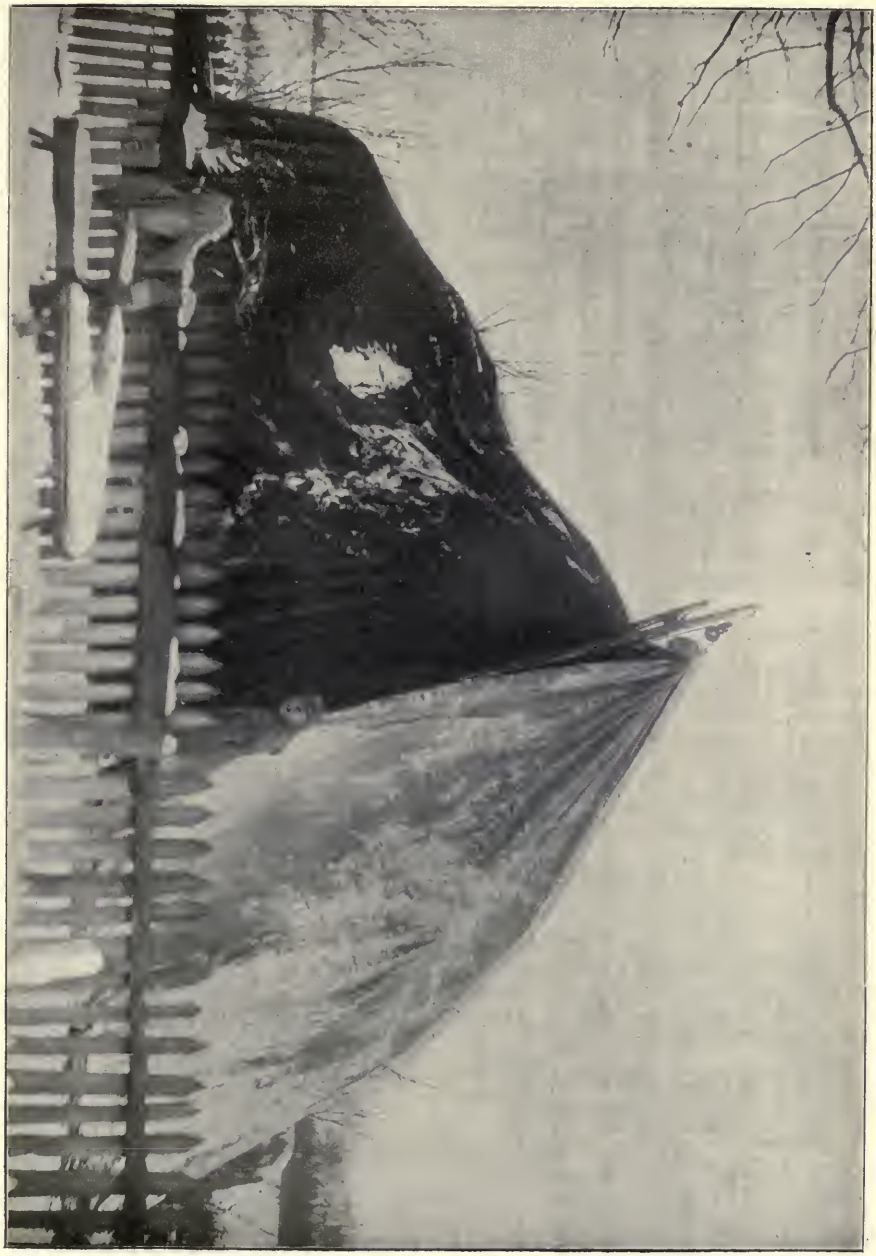


PLATE IV.

COVERING TREES WITH TWO TENTS LAPPED.

PLATE V.

LAPPED TENTS IN PLACE, COVERING TWO TREES AT ONCE.

PLATE VI.

FUMIGATING SMALL TREES.

PLATE VII.

PEAR-TREE THIRTY-FIVE FEET HIGH INFESTED BY SAN JOSE SCALE, NEAR SPARTA, ILL.

PLATE VIII.

TRIMMING AND SPRAYING PEACH-TREES.

PLATE IX.

PULLING OUT INFESTED HEDGE WITH STUMP-PULLER.

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